SRS

STANFORD RESEARCH SYSTEMS

SR850
DSP Lock-In Amplifier

SR850 DSP Lock-In Amplifier

$7500
(U.S. list price)

- **100 dB dynamic reserve without prefiltering (5ppm stability)**
- **1 mHz to 102 kHz bandwidth**
- **0.001° phase resolution**
- **Time constants from 10μs to 30 ks (6, 12, 18, 24 dB/oct rolloff)**
- **Synthesized reference oscillator**
- **64,000 point data display**
- **Data analysis including curve fitting, smoothing and statistics**
- **Direct plotting and printing**
- **3.5 inch MS-DOS compatible disk drive**
- **GPIB, RS-232, and printer interfaces**

Introducing the SR850 DSP Lock-In Amplifier from Stanford Research Systems - The next generation lock-in amplifier.

Digital Signal Processing

The SR850 is a dual phase lock-in amplifier that uses digital signal processing (DSP) to replace the demodulator, low-pass filters and DC gain amplifiers found in conventional lock-ins. With a state-of-the-art DSP chip and a high precision 18 bit A/D converter, the SR850 offers performance never before available to lock-in users - such as 0.001 degree phase resolution and 100 dB dynamic reserve.

The heart of any lock-in, the demodulator, determines how

much interference or noise can be tolerated by the instrument. Analog lock-ins must use input filters to achieve noise rejection greater than 60 dB and suffer the consequences - poor stability, output drift and excessive gain and phase error. Demodulation in the SR850 is achieved by digitizing the input signal, calculating a reference sine wave to 24 bits of accuracy, then performing an exact digital multiplication of the two signals. The result - the SR850 can easily reject interfering signals that are 1 million times (120 dB) larger than the signal being measured without using prefilters. And there is no gain error, output drift or stability penalty for using ultra-high dynamic reserve.

The digital signal processor also handles the task of output filtering. A choice of 6, 12, 18 or 24 dB/oct rolloff is provided for time constants ranging from 10 μs to 30 ks. When locked to frequencies below 200 Hz, synchronous filters are used to notch out multiples of the reference frequency. Even the F and 2F components are completely eliminated, meaning a much shorter output time constant can be used in low frequency measurements.

CRT Display

In addition to these performance advantages, the SR850 has some features new to lock-in amplifiers, such as a CRT display. Experimental data can now be viewed as it occurs. The screen can be formatted as a single or dual trace display. Bar graphs with numerical read-out, polar plots and strip chart displays enhance data interpretation.

The Bar graph and numerical read-out (fig. 1) resembles a conventional lock-in display. The graph indicates the percentage of full scale deflection and is useful in identifying fluctuations in the output. The large numeric read-outs can easily be seen from across the room. Polar plots (fig. 2) display the signal as a vector, providing a convenient way to view magnitude and phase. One of the most useful features of the SR850 is the chart display (fig. 3) which allows on-screen graphing of data in strip chart form. A time history of up to 64,000 data points can be recorded at rates up to 512 Hz,

eliminating the need for external chart recorders. Up to four chart traces can be independently configured as (AxB)/C or $(AxB)/C^2$ where A, B and C are selected from X, Y, R, ø, X noise, Y noise, R noise, frequency or the auxiliary A/D inputs. While data is being acquired, marks can be added to the charts to identify external events, such as a change in experimental conditions. Panning and zooming features allow close examination of any section of the data.

On-screen Analysis

The analysis capabilities of the SR850 seem limitless. Detection of any harmonic (2F to nF) up to 102 kHz is now possible. Auto measurement functions quickly optimize the gain, phase and dynamic reserve during data acquisition. Once data have been taken, powerful reduction routines including curve smoothing, curve fitting, statistics and math allow complex analysis without the aid of a computer.

Synthesized Reference Source

The internal oscillator uses direct digital synthesis (DDS) to provide a very low distortion (-80 dB) reference source. It is essentially a function generator with sine and TTL sync outputs capable of performing both linear and log sweeps over the entire 1 mHz to 102 kHz frequency range. When an external reference source is used, the internal oscillator phase locks to the source, and the sine and TTL outputs can be used to synchronize other equipment.

Inputs and Outputs

The voltage input (single-ended or differential) has a wide sensitivity range that extends from 2 nV to 1 V. A current input is also provided with a choice of 10^6 or 10^8 volts/amp gain ratios. Both X and Y components are updated by the DSP at 256 ksamples/sec and have dedicated analog outputs. Four auxiliary inputs (16 bit ADCs) are provided for general purpose use, such as normalizing signal to source intensity fluctuations or monitoring temperature. Four programmable outputs (16 bit DACs) are also provided and can have fixed or swept amplitudes. Two user defined outputs are easily configured as X, Y, R, ø, or chart traces 1 - 4.

Communication

Standard RS-232 and GPIB (IEEE-488) interfaces allow quick and easy communication with computers. The 3.5 inch MS-DOS compatible disk drive can store data traces and instrument setup files, or be used to transfer data to a PC for further analysis. Hardcopy outputs are available with dot matrix and LaserJet printers or HP-GL plotters.

Easy to Use Menus

And operating the SR850 is straightforward. All functions are menu driven. Soft keys are used to select options within a menu, and the spin knob and alpha-numeric keypad make parameter entry fast and simple. On-screen help provides a quick explanation for all functions of the instrument.

The SR850 DSP Lock-In Amplifier from Stanford Research Systems. A significant step forward in the development of lock-in amplifiers. For further information call us at (408)744-9040.

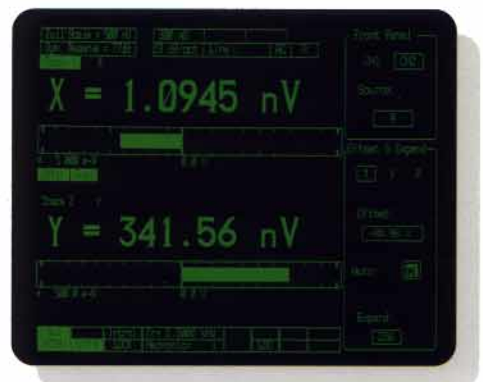


Figure 1 - Bar graph and numerical read-out resembles a conventional lock-in display.

Figure 2 - Polar plots illustrate the signal as a vector relative to the reference signal.

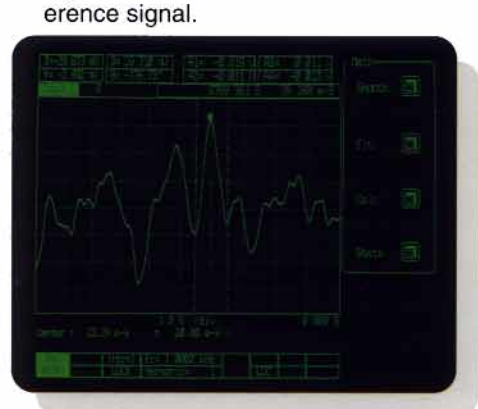


Figure 3 - Chart display allows on-screen data recording (64k points).

Specifications

SIGNAL CHANNEL

Voltage inputs	Single-ended or differential
Sensitivity	2 nV to 1 V
Current input	10^6 or 10^8 Volts/Amp
Impedance	Voltage: 10 MΩ + 25 pf, AC or DC coupled Current: 1 kΩ to virtual ground
Gain accuracy	± 1%
Noise	6 nV/√Hz at 1 kHz (typical) 0.13 pA/√Hz at 1 kHz (10^6 V/A) 0.013 pA/√Hz at 100 Hz (10^8 V/A)
Line filters	60 [50] Hz and 120 [100] Hz notch (Q=5)
CMRR	100 dB at 1 kHz
Dynamic reserve	0 to 100 dB (without prefilters)

REFERENCE CHANNEL

Frequency range	0.001 Hz to 102 kHz
Reference input	TTL or sine (200 mVp-p minimum)
Input impedance	1 MΩ, 25 pf
Phase resolution	0.001°
Absolute phase error	< 1°
Relative phase error	< 0.001°
Orthogonality	90° ± 0.001°
Phase noise	Internal reference oscillator : Synthesized, no phase noise. External reference applied: 0.005° rms at 1 kHz, 100 ms, 12 dB/oct.
Phase drift	< 0.01°/°C below 10 kHz, < 0.1°/°C below 100 kHz.
Harmonic detection	2F, 3F, ... nF to 102 kHz.
Acquisition time	2 cycles + 5 ms or 40 ms (whichever is greater)

DEMODULATOR

Stability	Digital outputs and display: no drift. Analog outputs: < 5 ppm/°C for all dynamic reserve settings.
Harmonic rejection	-90 dB
Offset / Expand	± 100% offset. Expand up to 256x.
Time constants	10 µs to 30 ks (6, 12, 18, 24 dB/oct rolloff). Synchronous filtering available below 200 Hz.

INTERNAL OSCILLATOR

Range	1 mHz to 102 kHz
Accuracy	25 ppm + 30µHz
Resolution	0.01% or 0.1 mHz, whichever is greater.
Distortion	-80dBc (f<10kHz). -70dBc (f>10kHz). 1 Vrms amplitude.
Amplitude	0.004 to 5 Vrms into 10 kΩ (2mV resolution). 50Ω output impedance.
Amplitude accuracy	1%
Amplitude stability	50 ppm/°C
Outputs	Sine and TTL. (When using an external reference, both outputs are phase locked to the external reference)
Sweeps	Linear and Log

INPUTS AND OUTPUTS

Interfaces	IEEE-488, RS-232 and Centronics printer interfaces standard. All instrument functions can be controlled and read through interfaces.
X, Y outputs	Sine and cosine components (± 10V). Updated at 256 ksamples/sec.
CH1 output	± 10V output of X, R, or Trace 1- 4 (each trace defined as AxB/C or AxB/C^2 where A, B, C are selected from X, Y, R, ø, X noise, Y noise, R noise, Aux 1-4 or frequency).
CH2 output	± 10V output of Y, ø or Trace 1- 4 (each trace defined as AxB/C or AxB/C^2 where A, B, C are selected from X, Y, R, ø, X noise, Y noise, R noise, Aux 1-4 or frequency).
Aux. A/D inputs	4 BNC inputs, 1 mV res., ± 10 V.
Aux. D/A outputs	4 BNC outputs, 1 mV resolution, ± 10 V, (fixed or swept amplitude).
Sine Out	Internal oscillator analog output.
TTL Out	Internal oscillator TTL output.
Trigger In	TTL signal either starts internal oscillator sweeps or triggers instrument data taking (rates to 512 Hz).
Remote pre-amp	Provides power to the optional SR550 and SR552 preamplifiers.

DISPLAYS

Screen format	Single or dual display.
Displayed quantities	Each display shows one trace. Traces are defined as AxB/C or AxB/C^2 where A, B, C are selected from X, Y, R, ø, X noise, Y noise, R noise, Aux 1 - 4 or frequency.
Display types	Large numeric readout with bar graph, polar plot or strip chart.
Data buffer	64k data points can be stored and displayed as strip charts. The buffer can be configured as a single trace with 64k points, 2 traces with 32k points each, or 4 traces with up to 16k points each. Sample rates are from 512 Hz to one point every 16 seconds, or externally triggered.

ANALYSIS FUNCTIONS

Smoothing	5, 9, 17, 21 or 25 point Savitsky-Golay smoothing.
Curve fitting	Linear, exponential or Gaussian
Calculator	Arithmetic, trigonometric and logarithmic calculations on trace region.
Statistics	Mean and standard deviation of trace region.

GENERAL

Hardcopy	Screen dumps to dot matrix or LaserJet printers. Plots to HP-GL compatible plotters (RS-232 or GPIB).
Disk drive	3.5 inch MS-DOS compatible format, 720 kbyte capacity. Storage of data and instrument setups (binary or ASCII). Screens can be saved to disk as PCX files.
Power	60 Watts, 100/120/220/240 VAC, 50/60 Hz.
Dimensions	17"W x 6.25"H x 19.5"L
Weight	40 lbs.
Warranty	One year parts and labor.

A bit about DSP

Digital signal processing (DSP) is commonly used to replace specialized analog circuits in a system with specific mathematical computations. In a lock-in amplifier, DSP can be used to eliminate the demodulator, output filters and DC gain circuits, and enhance the performance of the instrument.

All conventional lock-ins suffer from problems in the demodulator where an analog input signal is mixed with an analog reference signal. If you can digitize the input signal and calculate a reference sine wave to a high enough degree of accuracy, you can demodulate the two signals by performing a digital multiply. In principle, you cannot do better than multiplying a digitized number by a calculated number. There are no mistakes, no drifts, and no errors.

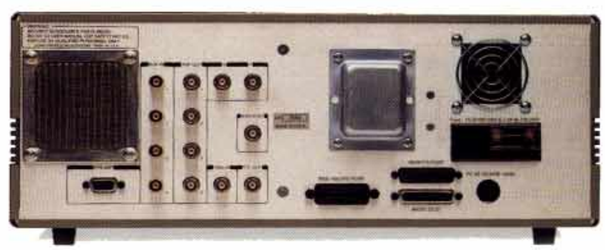
The SR850 uses a precision 18 bit ADC to convert the input signal to a digital bit stream. The DSP, which is locked to the reference signal, calculates a pure sine reference for the multiply. Because the calculated sine reference signal is generated with 24 bits of accuracy, the phase resolution and orthogonality are 0.001°, or 1000 times better than a conventional lock-in.

The DSP performs sixteen million 24-bit multiplies and adds each second and produces an answer accurate to 48 bits. This results in 100 dB of real dynamic reserve (no prefiltering) free of the gain errors, output drift and noise penalties common to analog lock-ins. The SR850 maintains 5 ppm/°C stability even at a dynamic reserve of 100 dB. In contrast, analog lock-ins have about 20 dB of dynamic reserve at 5 ppm/°C stability.

Finally, the replacement of the output filter circuits by a pure mathematical calculation allows additional flexibility and improved performance. The filter rolloff is now simply a function of the filtering algorithm, and 6, 12, 18 and 24 dB/oct can all be offered. Furthermore, time constants can be varied from 10 μsec to 30,000 seconds with no associated error or costly circuitry. With the aid of DSP technology, the SR850 has become the most effective lock-in amplifier available for extracting a small signal from a noisy background.

Rear Panel

The rear panel of the SR850 includes standard IEEE-488 (GPIB) and RS-232 computer interfaces, printer port, keyboard connector (IBM compatible) for text and numeric entry, remote preamplifier power connector, four ADC inputs, four DAC outputs, trigger input, TTL reference output, signal monitor output, and X and Y outputs.



Ordering Information (all prices U.S. list)

SR850

DSP Lock-In Amplifier $7500

OPTIONS

SR540 Chopper	$1095	*4 Hz to 4 kHz, 4 digit display, input control voltage.*
SR550 Preamplifier	$595	*2.8 nV/√Hz input noise, 100 MΩ input impedance.*
SR552 Preamplifier	$595	*1.4 nV/√Hz input noise, 100 kΩ input impedance.*
0850H Handle Kit	$100	

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